THE UNIVERSITY OF TEXAS AT AUSTIN
CENTER FOR ENERGY AND ENVIRONMENTAL RESOURCES

Annual Variability in Leaf Area Index and Isoprene/Monoterpene Emissions in Texas during Drought Years

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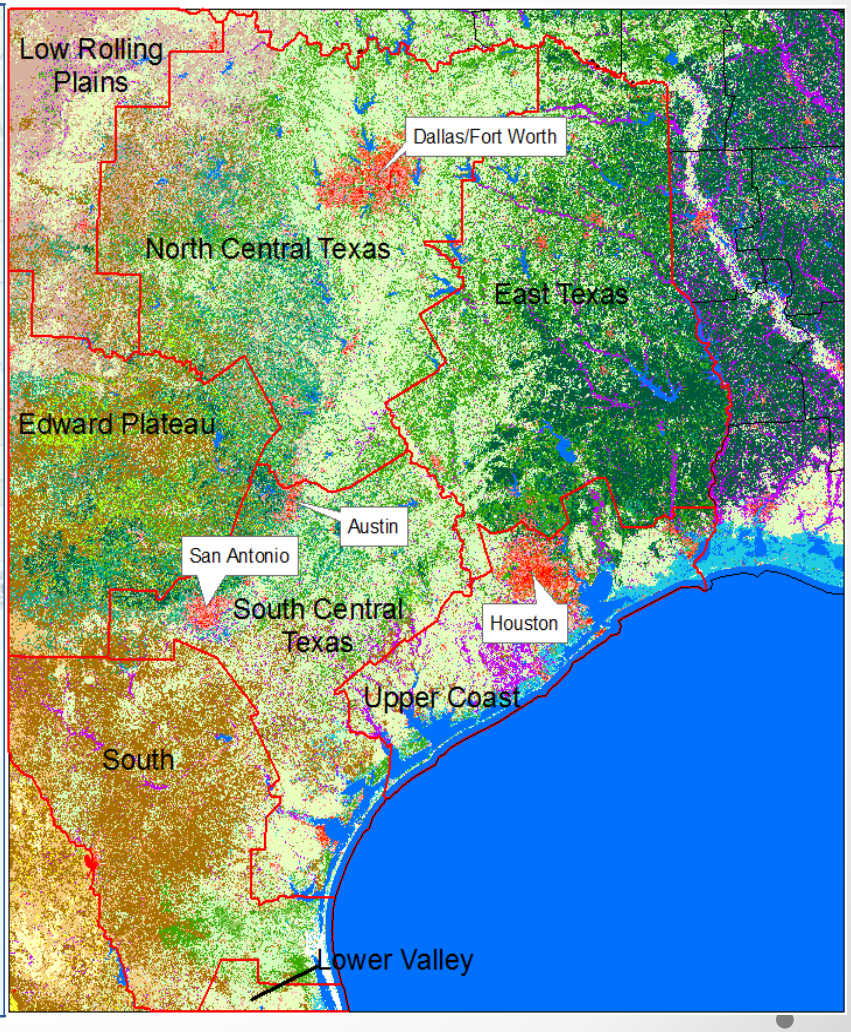
BACKGROUND

- Emissions of biogenic volatile organic compounds (BVOCs) from vegetation can have substantial impacts on ozone and fine particle formation in Texas
- Isoprene and monoterpenes are quantitatively the most important BVOCs emitted from vegetation
- Factors affecting model predictions of biogenic emissions include: vegetation type, meteorological variables (e.g. temperature, surface insolation), soil moisture, leaf area index (LAI)
- Drought may have substantial impacts on biogenic emissions.
- One mechanism is through drought-induced changes in LAI but quantitative relationship is poorly understood

OBJECTIVE

- Calculate interannual variations in LAI during 2006-2011, which includes years with extreme to exceptional drought (e.g. 2006, 2011) as well as wet years (e.g., 2007)
- Quantify the interannual variations of predicted isoprene and monoterpene emissions due to variations in LAI
- Analyze the relative influence of LAI vs. meteorological variations on predictions of isoprene/monoterpene emissions

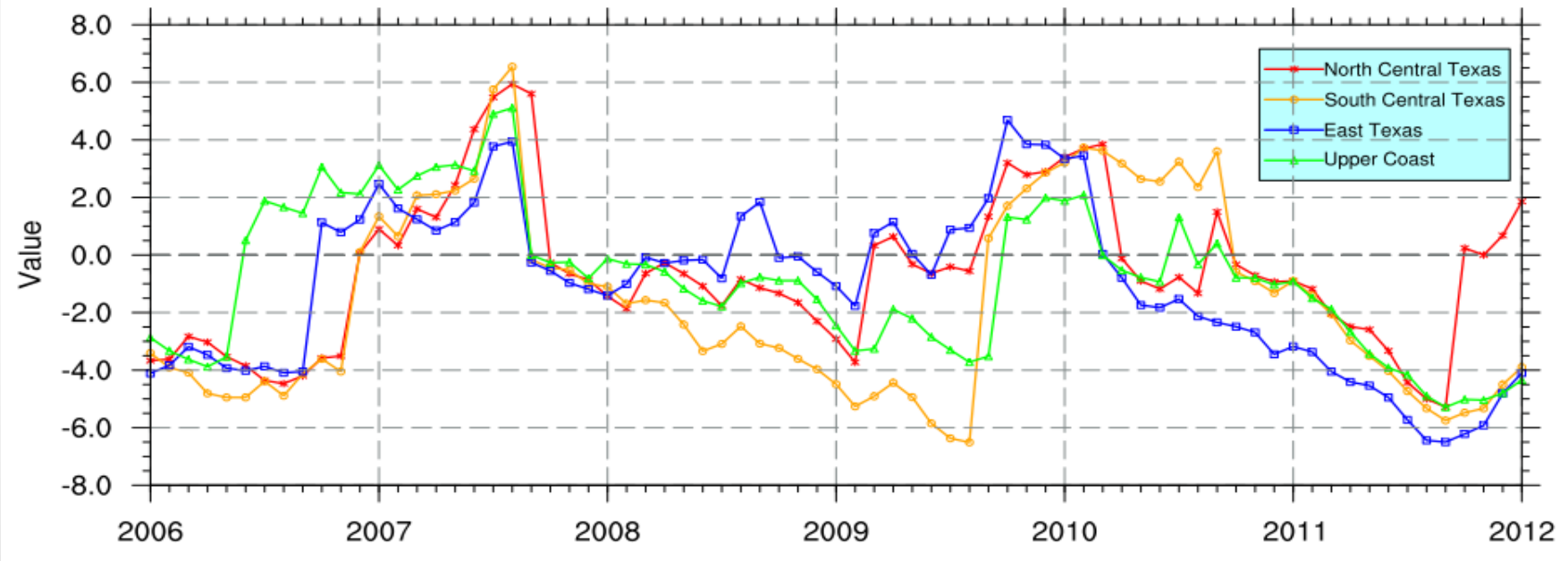
Climate Divisions



(Source: Popescu et al., 2011)

Study Years (2006 – 2011)

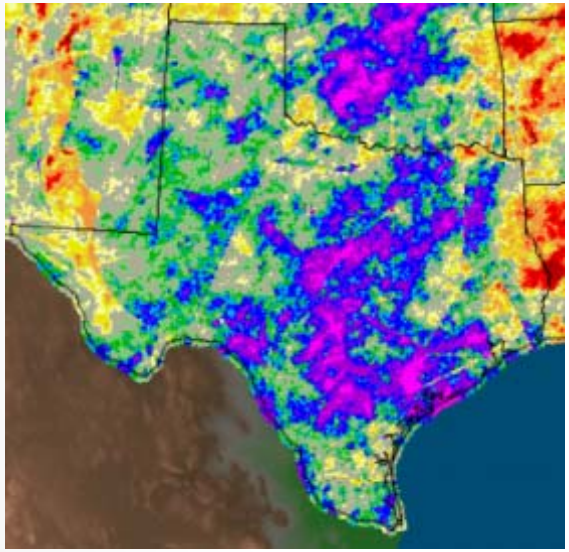
- Monthly PDSI (Palmer Drought Severity Index)



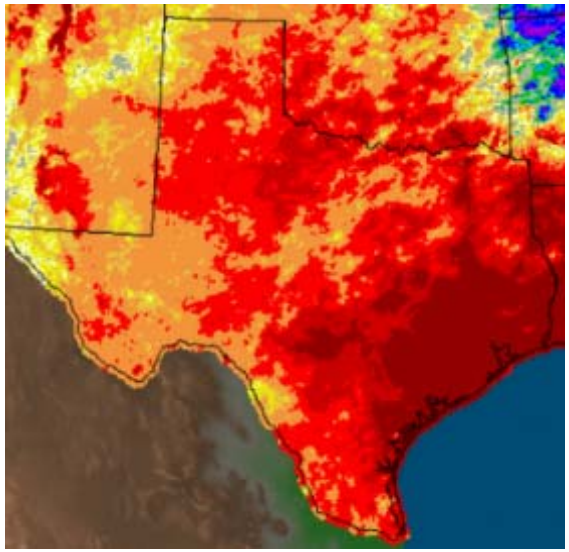
Data Source: National Climatic Data Center

Study Years (2006 – 2011)

- Annual precipitation (departure from mean)



2007 (wet)

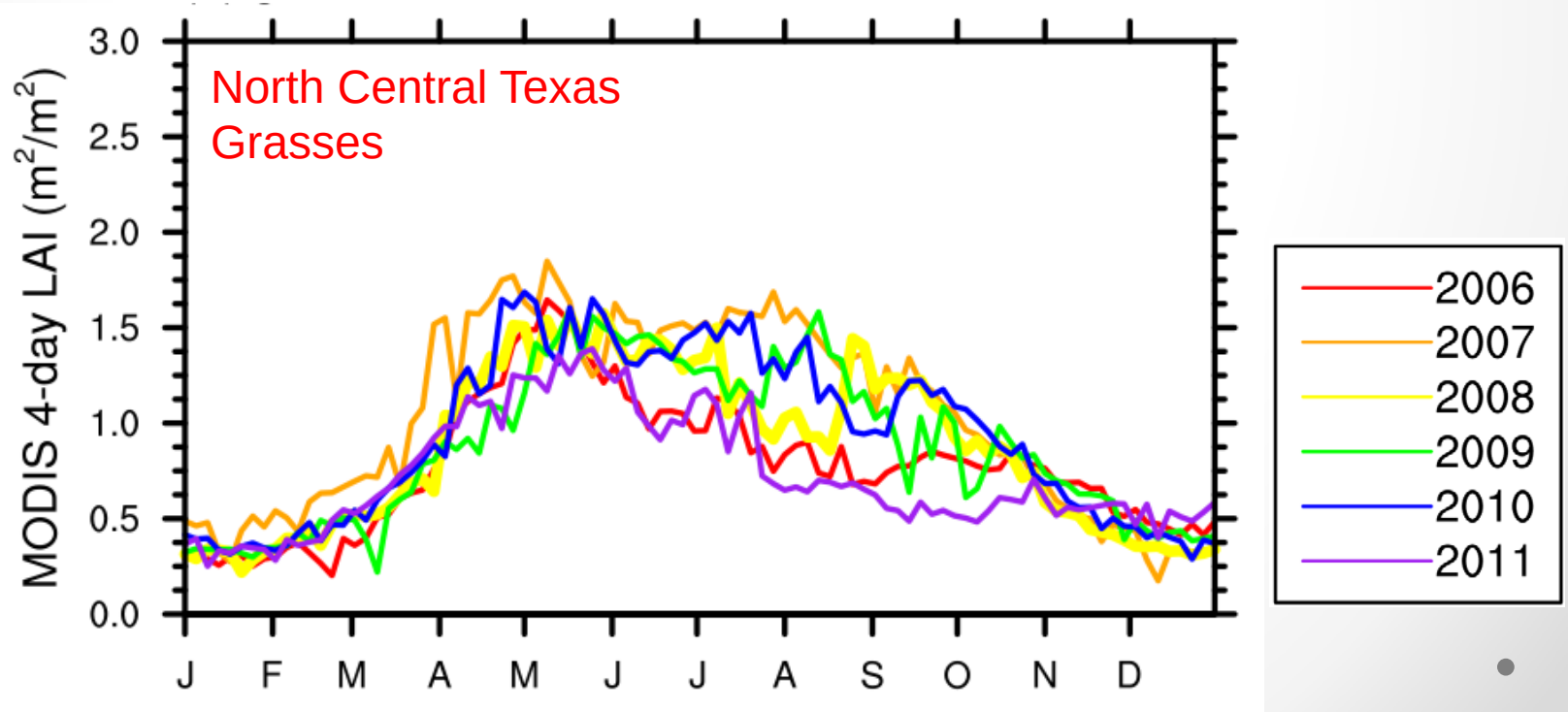


2011 (dry)

Map Source: National Weather Service – Advanced Hydrologic Prediction Service

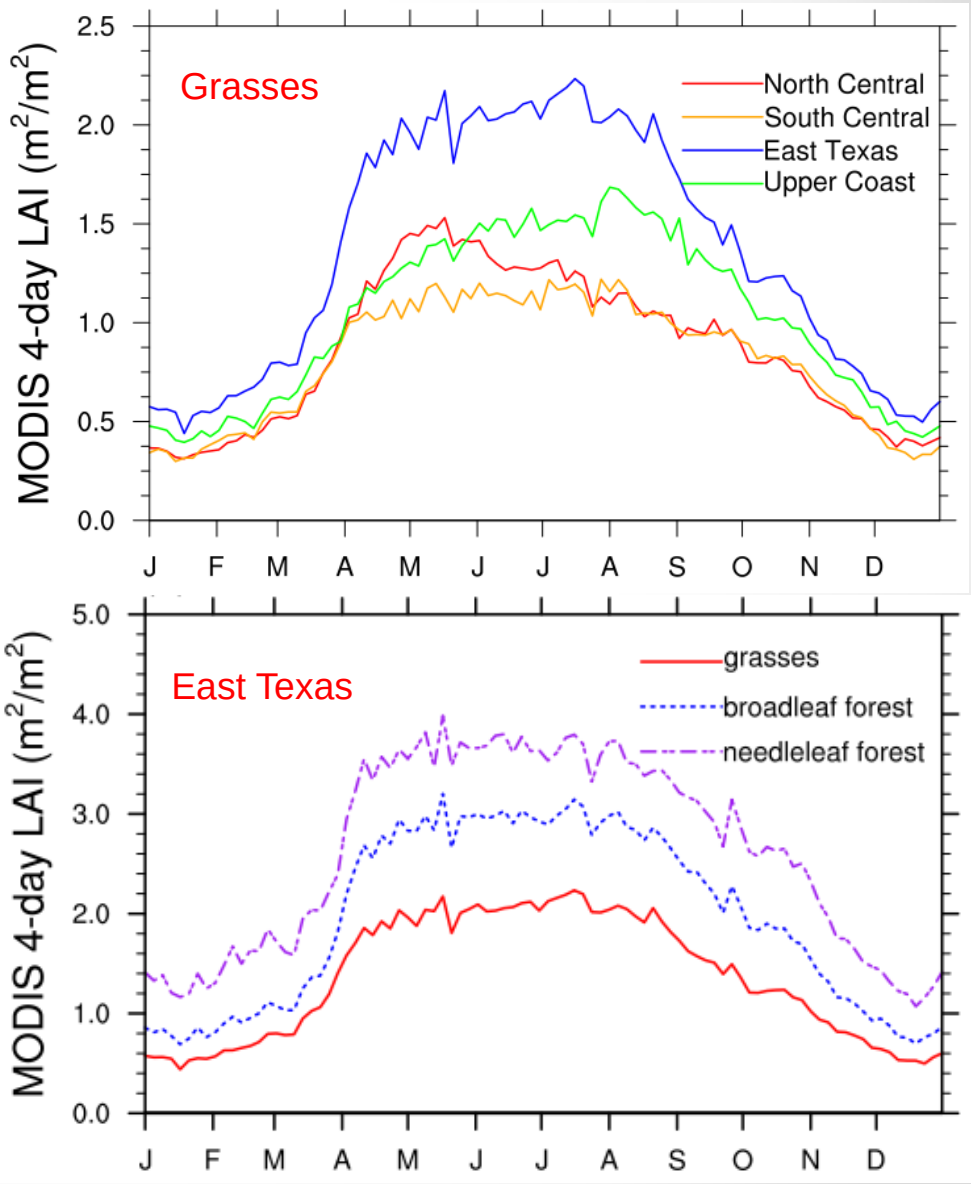
Results – LAI Variability

- MODIS 4-day LAI product
  - Previous biogenic emission studies have utilized the 8-day product
- Strong LAI seasonal pattern: lowest in winter, highest during April – October



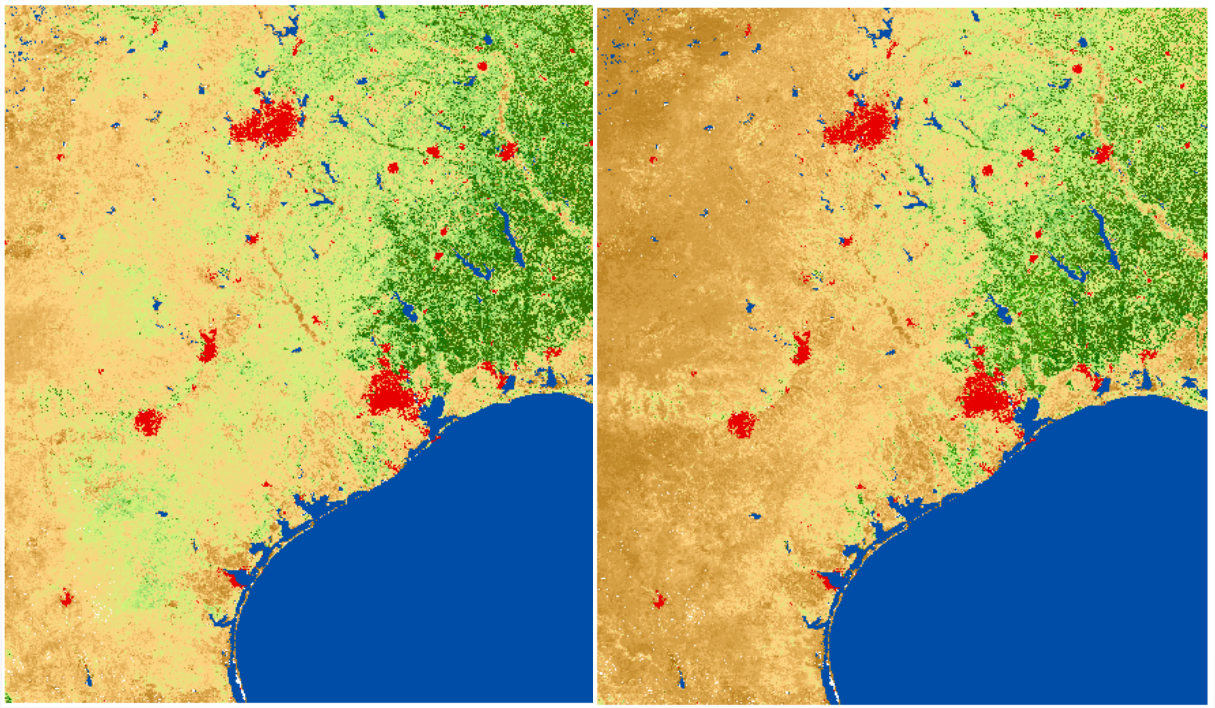
Results - LAI Variability

- LAI varies across different land cover types and climate regions
- East Texas > Upper Coast > North/South Central Texas
- East Texas shows the most substantial LAI variations across different land cover types: needleleaf forest (~4 m^2/m^2) > broadleaf forest (~3 m^2/m^2) > grasses (~2 m^2/m^2)



Results - LAI in Drought/Wet Years

- More rapid inland greening during wet than dry year

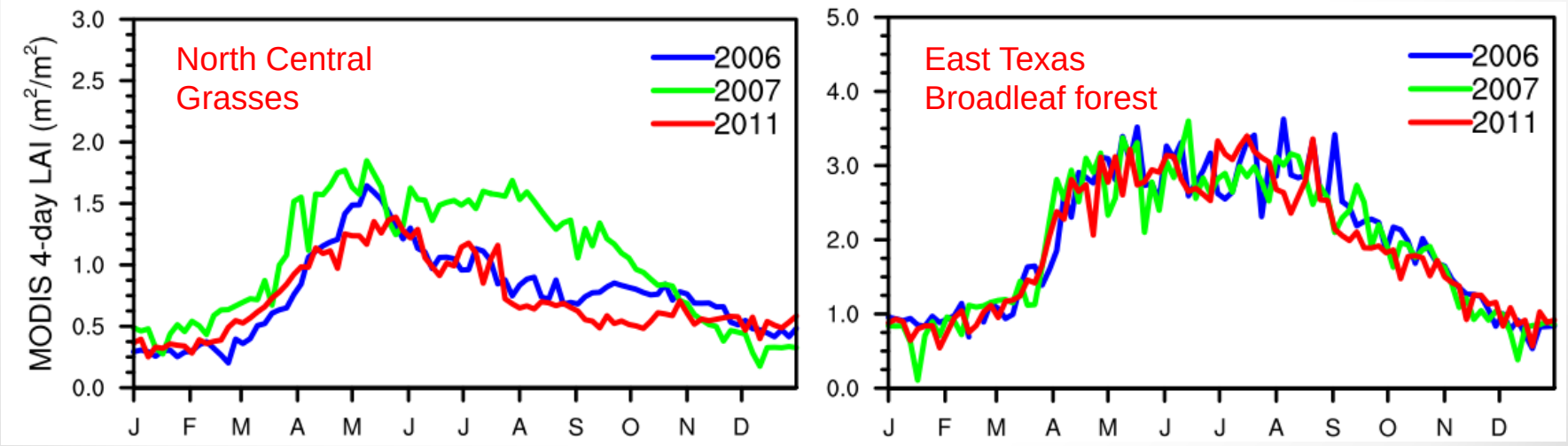


April 3rd, 2007 (wet)

April 3rd, 2011 (dry)

Results - LAI in Drought/Wet Years

- North/South Central Texas showed substantial LAI reductions between wet and drought years
- East Texas/Upper Coast exhibits relatively less reduction in LAI for drought years
- North/South Central Texas had greater LAI annual variations (> 20%) than East Texas/Upper Coast (< 20%)



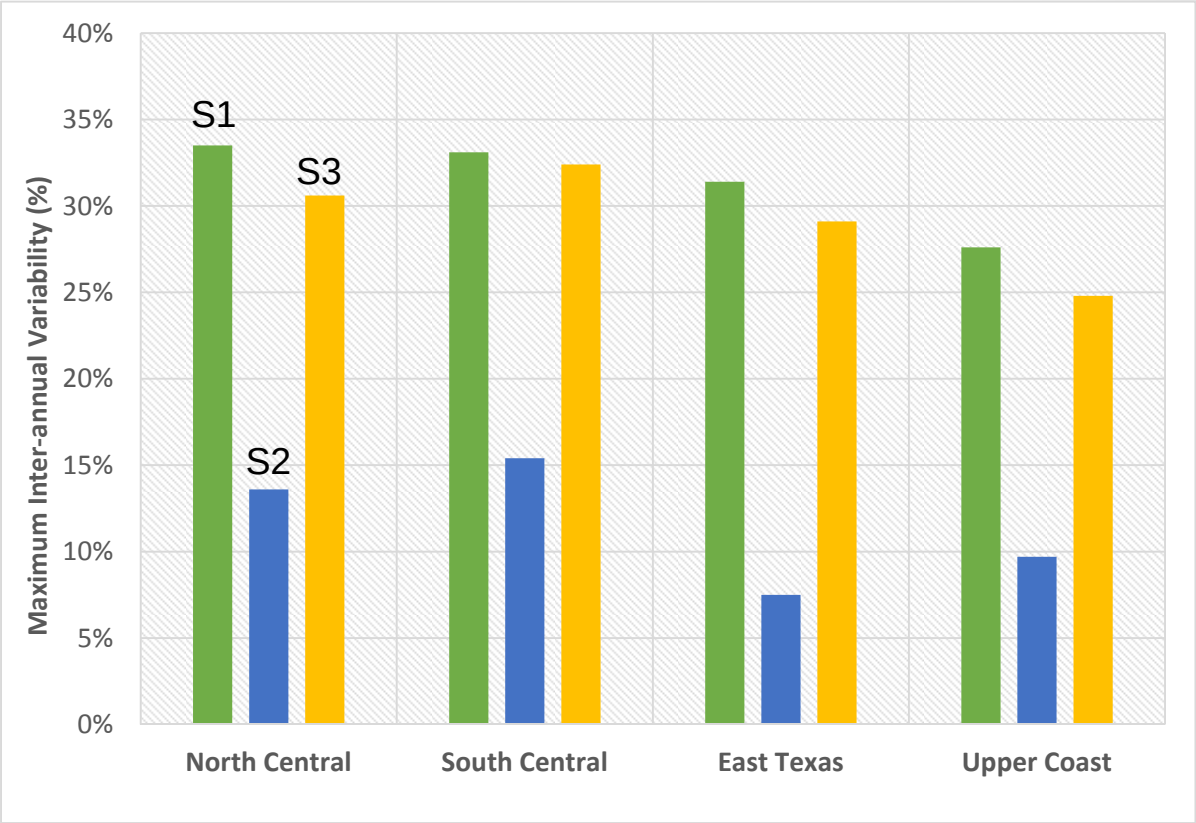
Results – Biogenic Emissions Simulations

- MEGAN (Model of Emissions of Gases and Aerosols from Nature)
- Inputs: LAI, land cover, meteorological fields (National Centers for Environmental Prediction's North American Regional Reanalysis), satellite insolation (University of Alabama at Huntsville)
- Three MEGAN simulations over 2006 – 2011:
  - S1: year-specific LAI + year-specific meteorological fields
  - S2: year-specific LAI + constant meteorological fields
  - S3: constant LAI + year-specific meteorological fields
- Interannual variability: $$IAV = \frac{1}{n}\sum_{y=1}^{n}\left|\frac{x_{y,m} - \overline{x_m}}{\overline{x_m}}\right| \times 100$$

Source: Tawfik et al. (2012)

Results – Interannual variability of isoprene emissions

- Interannual variability (S1) ranged from a maximum of 27% for Upper Coast to 34% for North Central
- Variations of isoprene emissions due to LAI variations (S2) were >10% in central regions but <10% in East Texas and Upper Coast
- Meteorological fields (S3) collectively had a greater influence than LAI alone
- LAI and meteorological fields may have competing effects



S1: year-specific LAI + met.
S2: year-specific LAI + constant met.
S3: constant LAI + year-specific met.

CONCLUSIONS

- LAI exhibits substantial spatial and temporal variations across climate divisions and land cover types within the eastern half of Texas
- LAI reductions during drought years were substantial in regions with low-growing vegetation (North/South Central Texas) but were minimal in heavily forested areas (East Texas)
- Estimates of biogenic emissions were more influenced by interannual variability in meteorology relative to LAI, but evidence of competing effects is under investigation